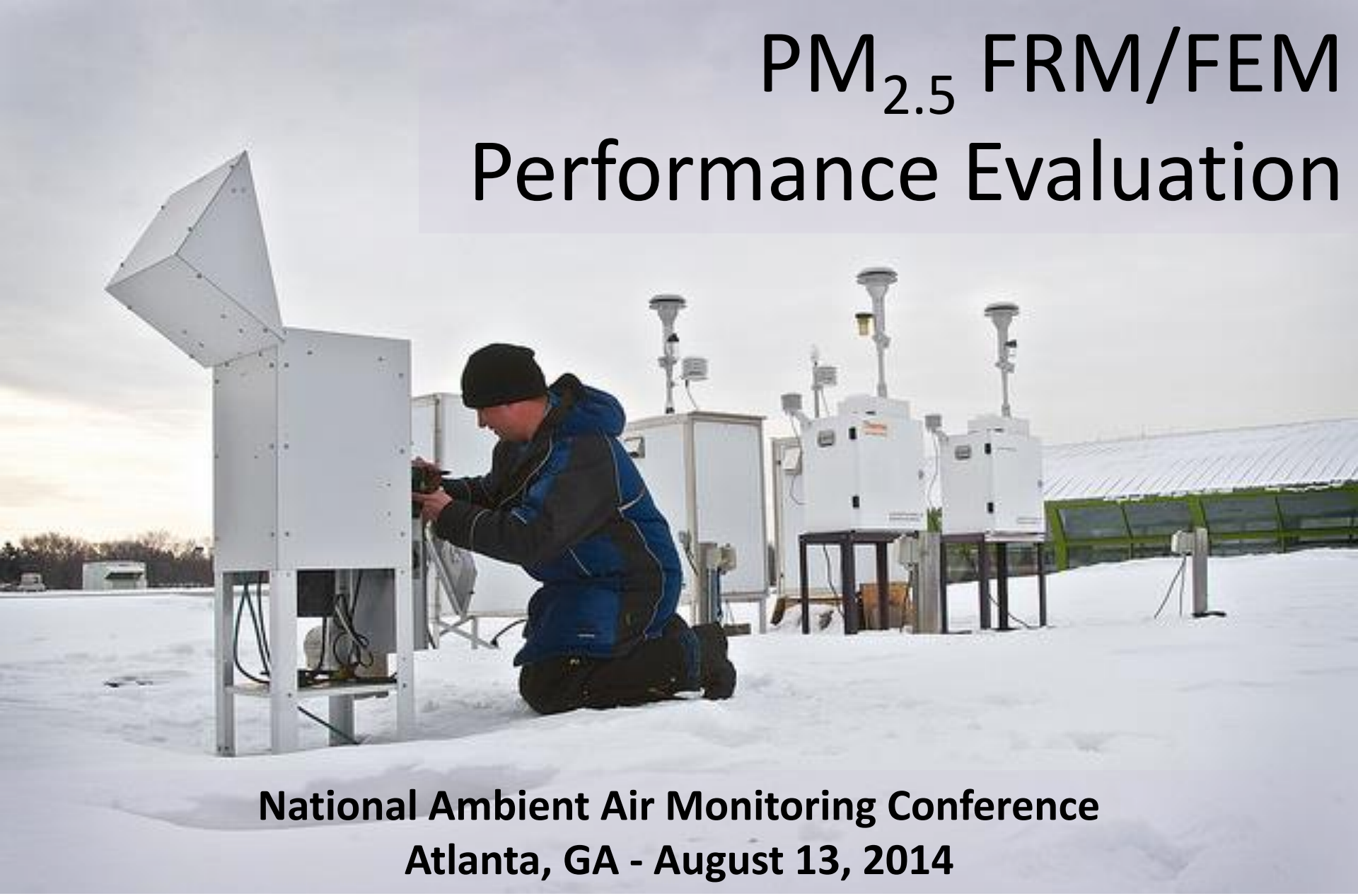
$PM_{2.5}$ FRM/FEM Performance Evaluation



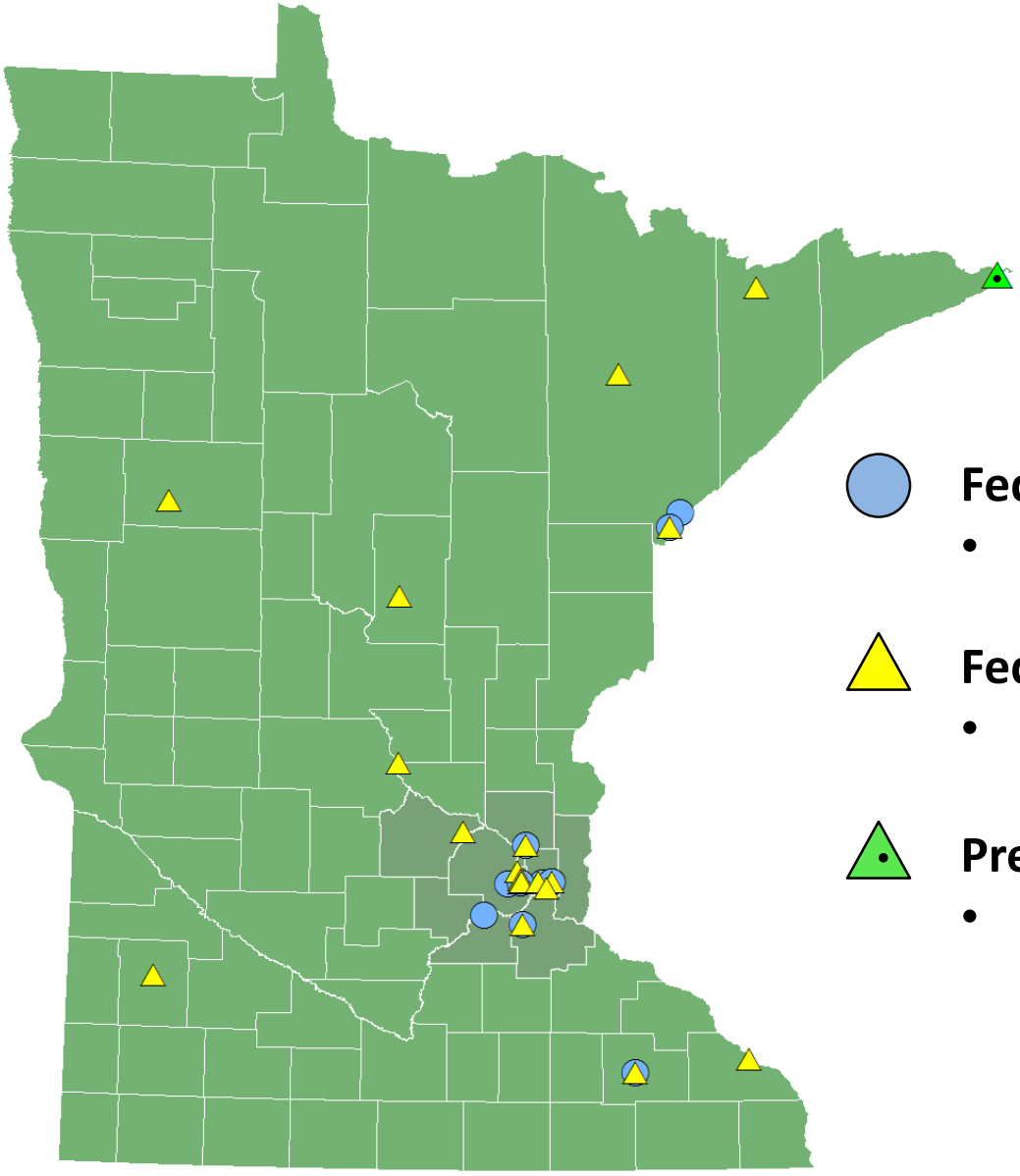
National Ambient Air Monitoring Conference
Atlanta, GA - August 13, 2014

Minnesota Pollution Control Agency

Topics Covered

- Minnesota's $PM_{2.5}$ Monitoring Network
- Performance Evaluation Methods and Metrics
- Results
  - Historic FRM/BAM relationship
  - Current FRM/FEM relationship
- Lessons Learned

$PM_{2.5}$ Monitoring in Minnesota



2014 Network Description

Federal Reference Method Sites

- 10 x Thermo Partisol-Plus 2025

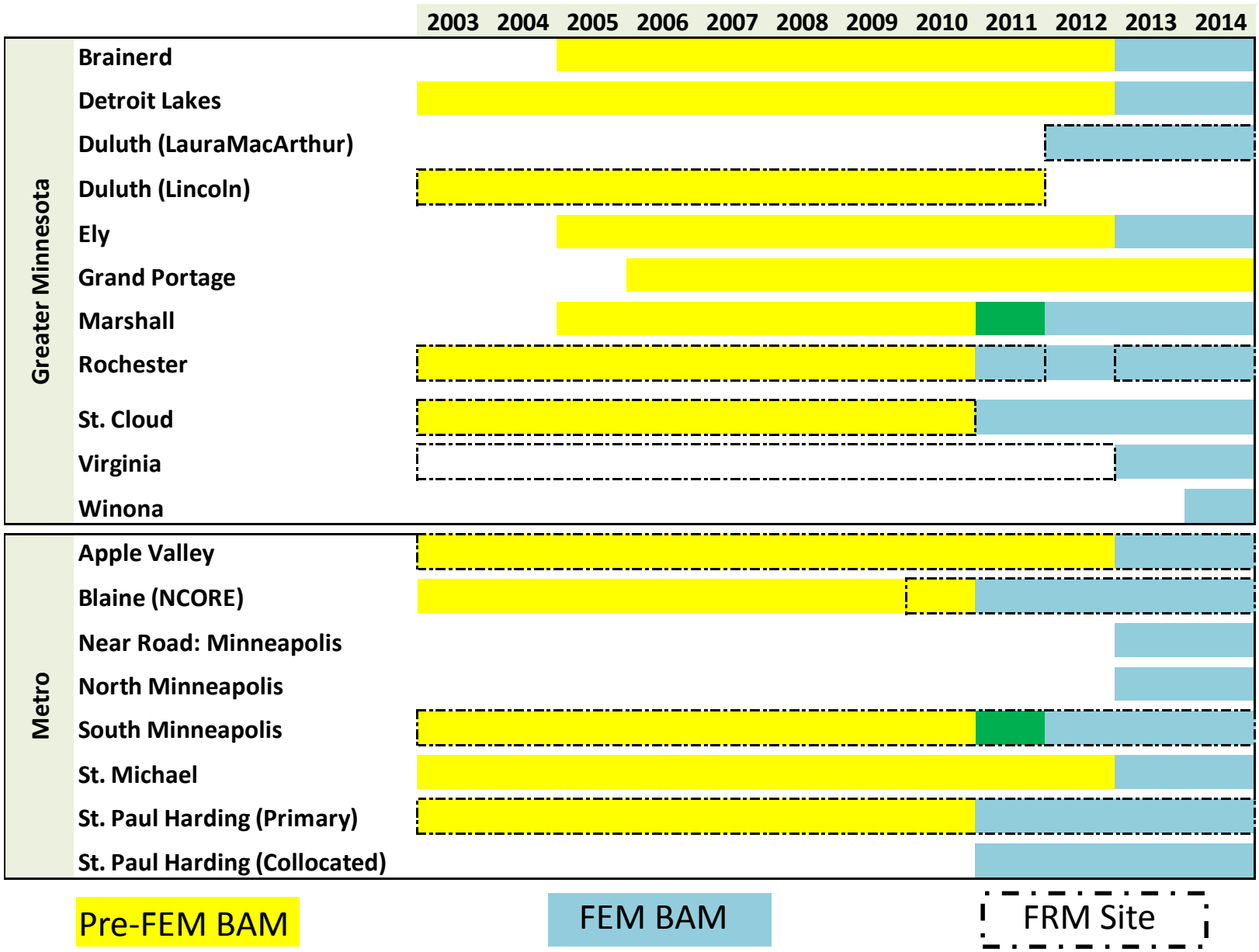
Federal Equivalent Method Sites

- 16 x MetOne BAM-1020

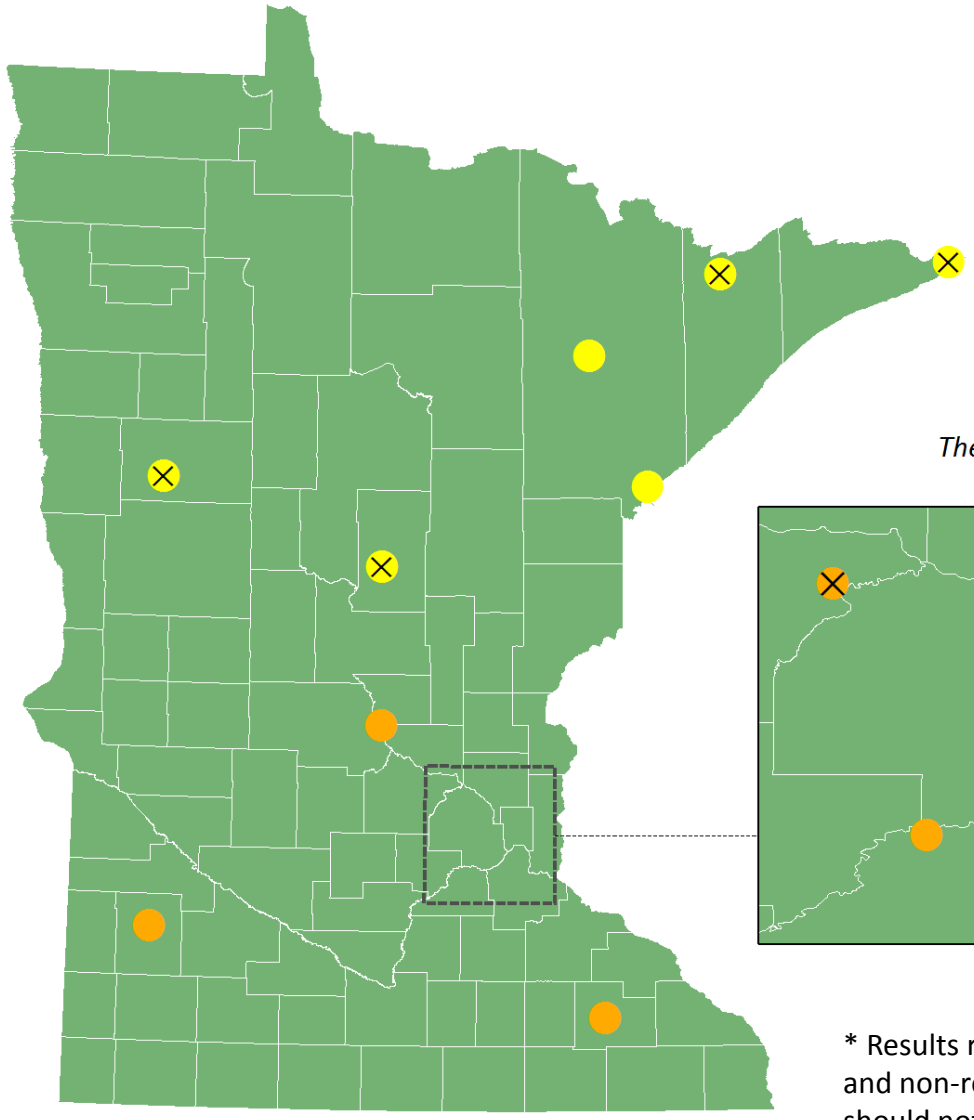
Pre-FEM BAM Sites

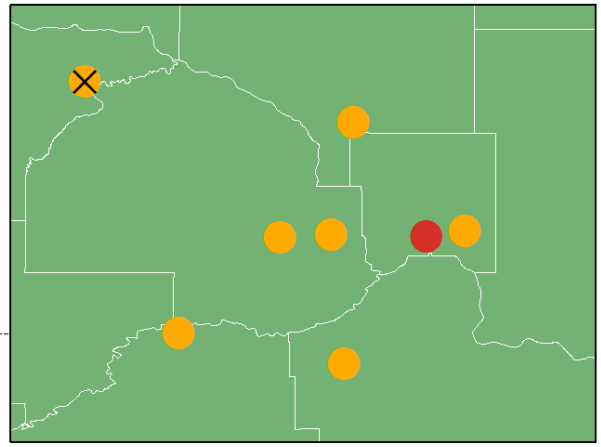
- 1 site operated by the Grand Portage Band of Lake Superior Chippewa

Semi-Continuous $PM_{2.5}$ Monitor History



Annual $PM_{2.5}$ Design Values* in Minnesota





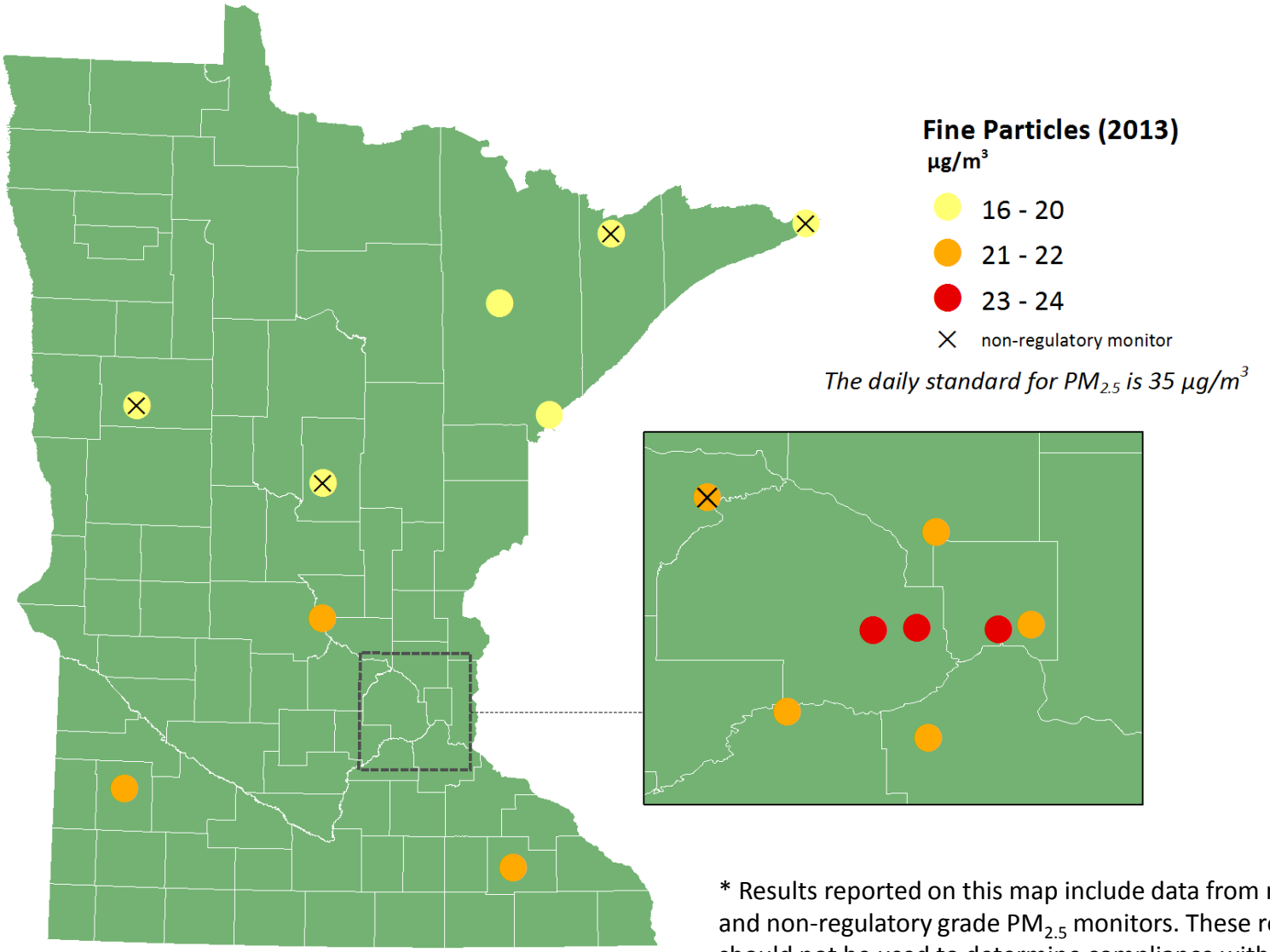
Fine Particles (2013)
µg/m³

- 5.3 - 7.0
- 7.1 - 9.0
- 9.1 - 9.8
- × non-regulatory monitor

The annual standard for $PM_{2.5}$ is 12 µg/m³

* Results reported on this map include data from regulatory and non-regulatory grade $PM_{2.5}$ monitors. These results should not be used to determine compliance with the NAAQS.

Daily $PM_{2.5}$ Design Values* in Minnesota



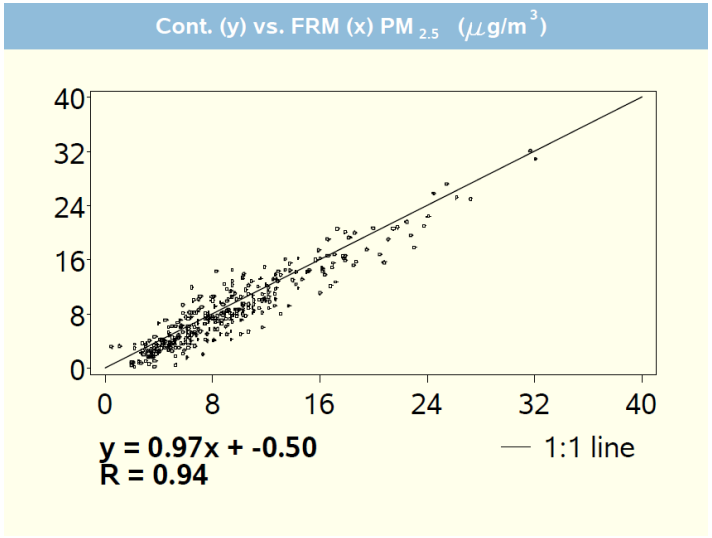
* Results reported on this map include data from regulatory and non-regulatory grade $PM_{2.5}$ monitors. These results should not be used to determine compliance with the NAAQS.

Performance Evaluation Methods and Metrics

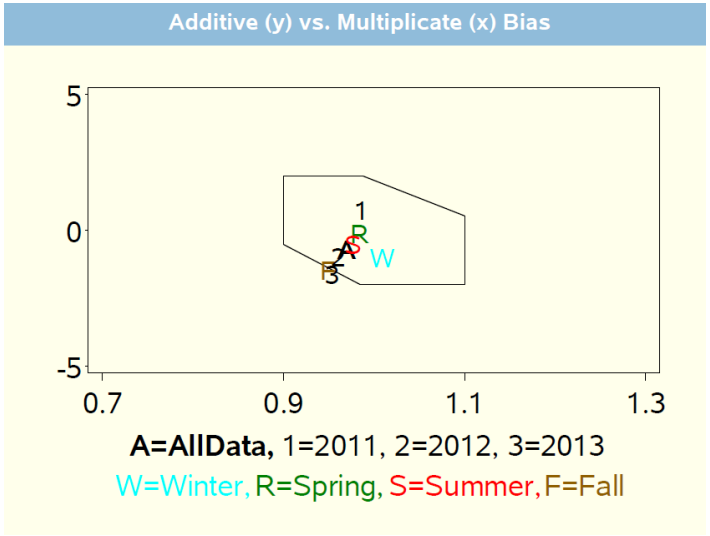
$PM_{2.5}$ Continuous Monitor Comparability Assessments

(http://www.epa.gov/airquality/airdata/ad_rep_frmvfem.html)

Linear Regression (XY Plot)

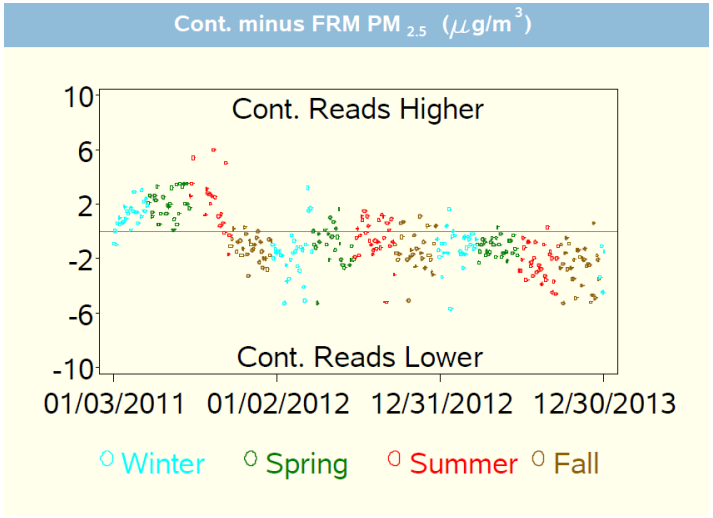


Slope and Intercept Limits (Box Test)



Performance Evaluation Methods and Metrics

Sample Concentration Difference Time Series



Mean Concentration Ratios

Mean $PM_{2.5}$ ($\mu g/m^3$)

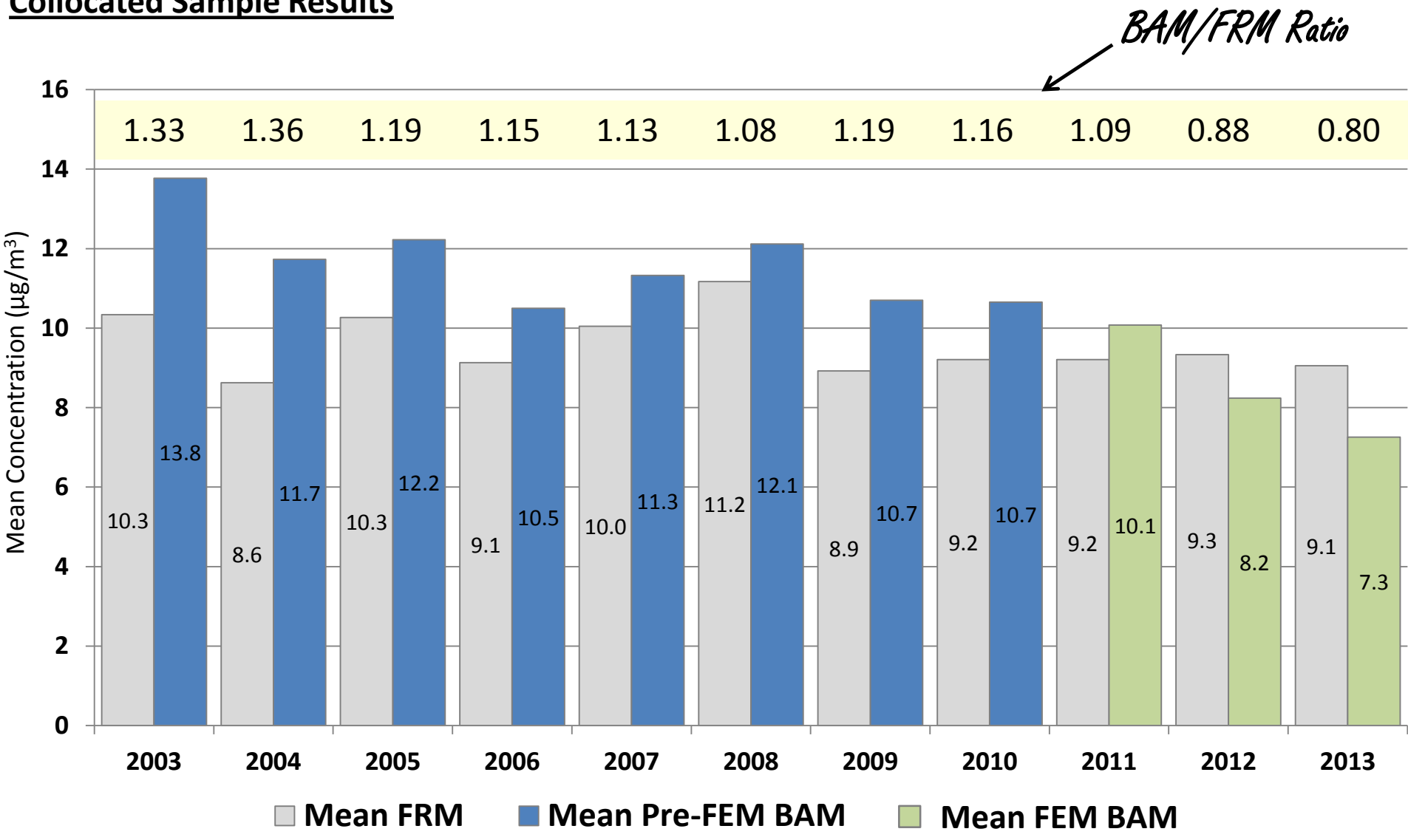
Dataset	N	FRM	Cont	Ratio (Cont/FRM)
AllData	**335**	**9.2**	**8.4**	**0.91**
Winter	87	11.2	10.4	0.93
Spring	83	7.1	7.0	0.99
Summer	79	9.0	8.5	0.94
Fall	86	9.4	7.6	0.81
2011	104	9.2	10.0	1.09
2012	111	9.3	8.2	0.88
2013	120	9.1	7.2	0.80

Also available from Air Data report:

- R (y) versus FRM CCV (x)
- Appendix A Statistics (Bias)

Results: FRM versus BAM

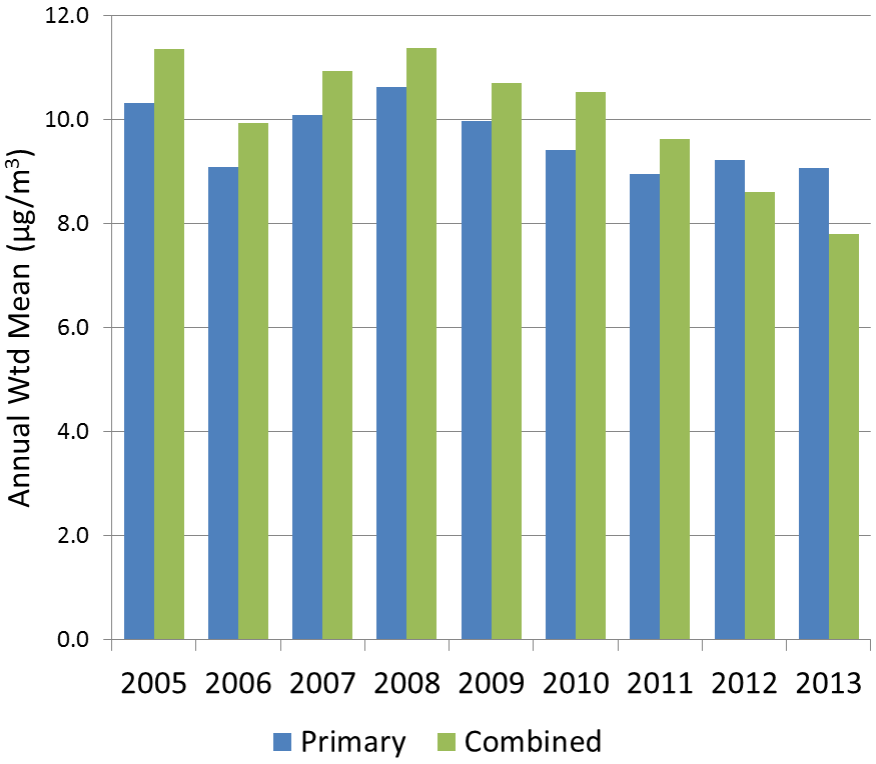
Collocated Sample Results



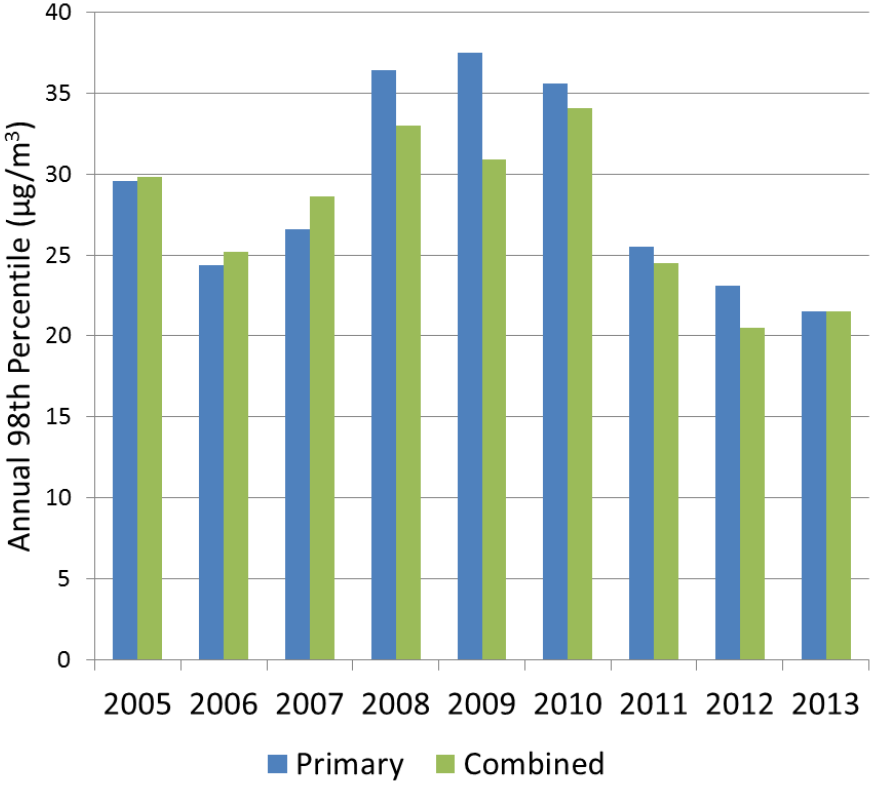
Results: FRM versus BAM

Primary versus Combined Record for DVs

Annual Seasonally -Weighted Mean

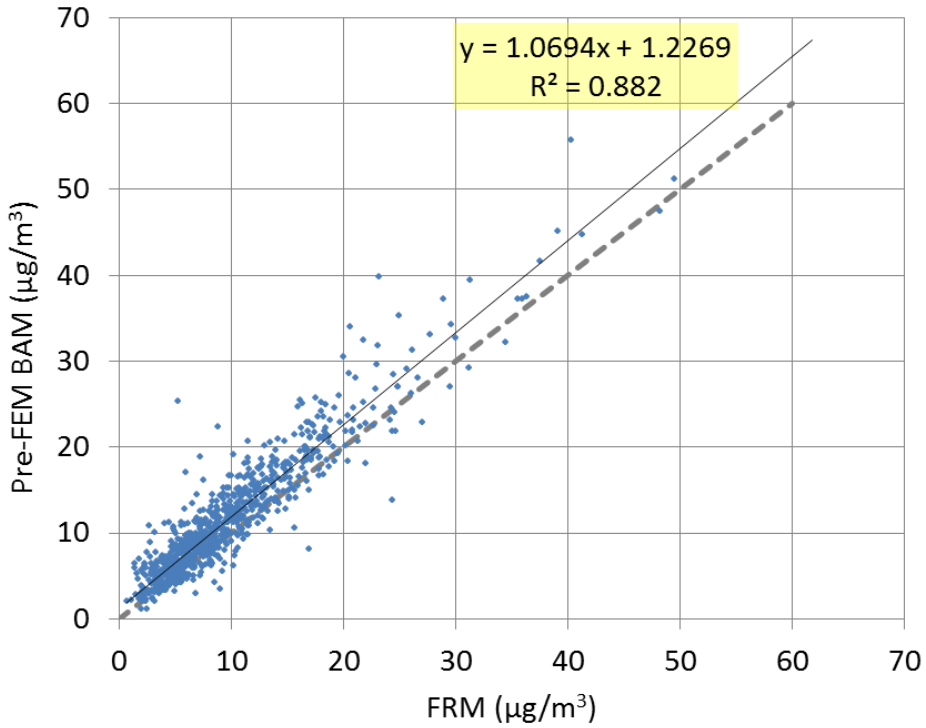


Annual 98th Percentile Daily Mean

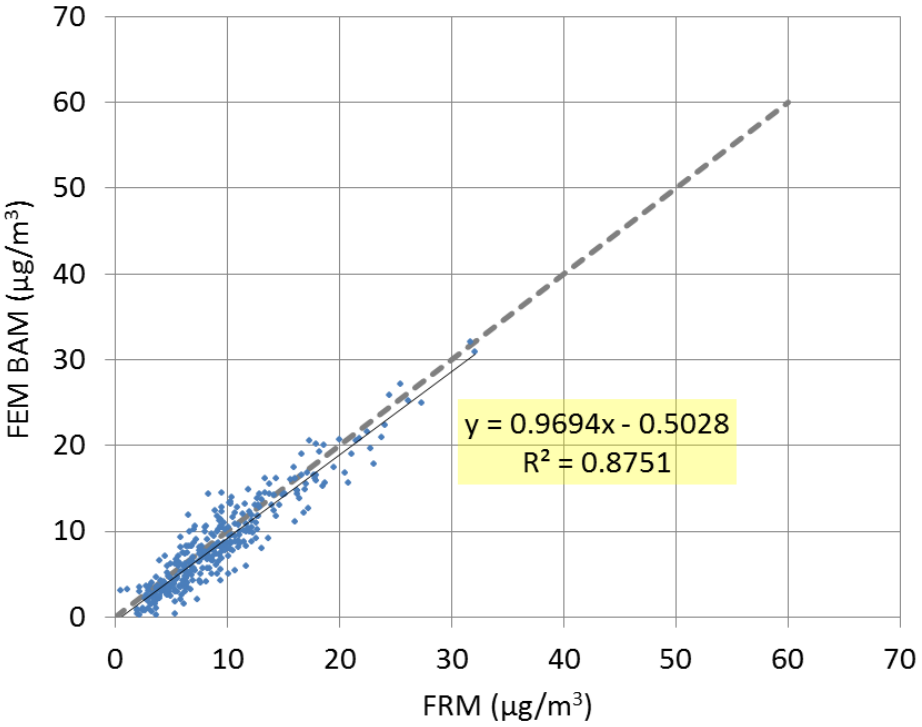


Results: FRM versus BAM

Pre-FEM BAM (Y) vs FRM (X) 2003-2010

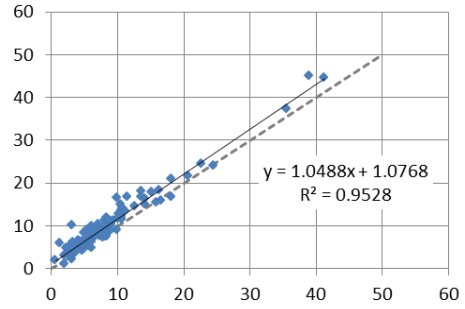


FEM BAM (Y) vs FRM (X) 2011-2013

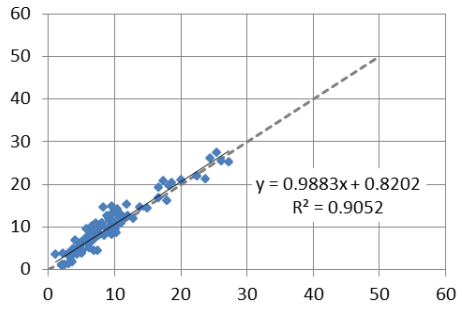


Results: FRM versus BAM

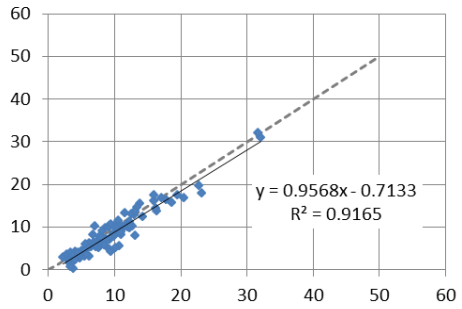
2010



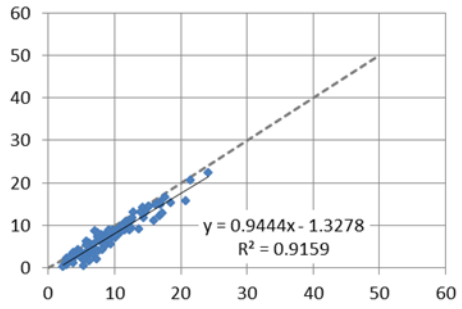
2011

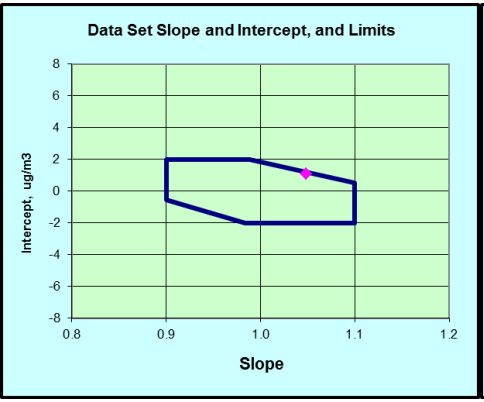


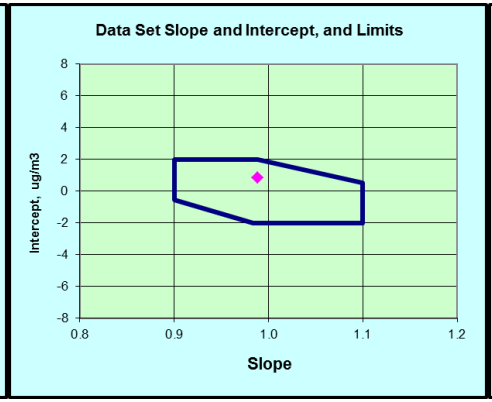
2012

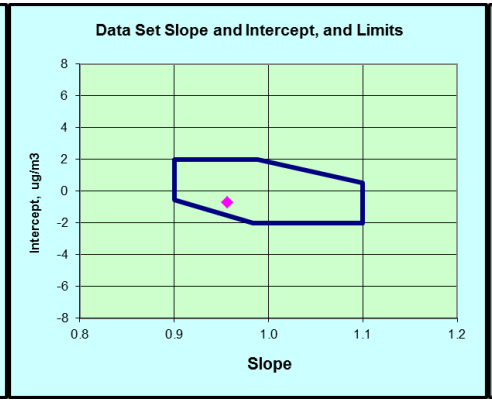


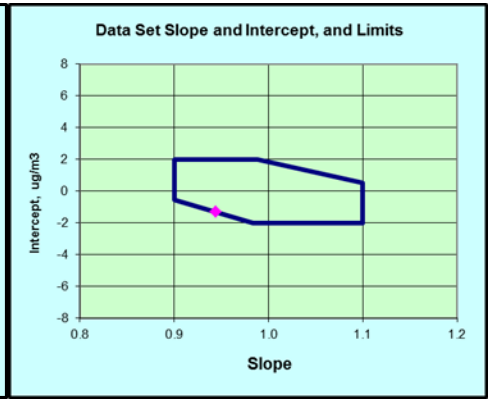
2013





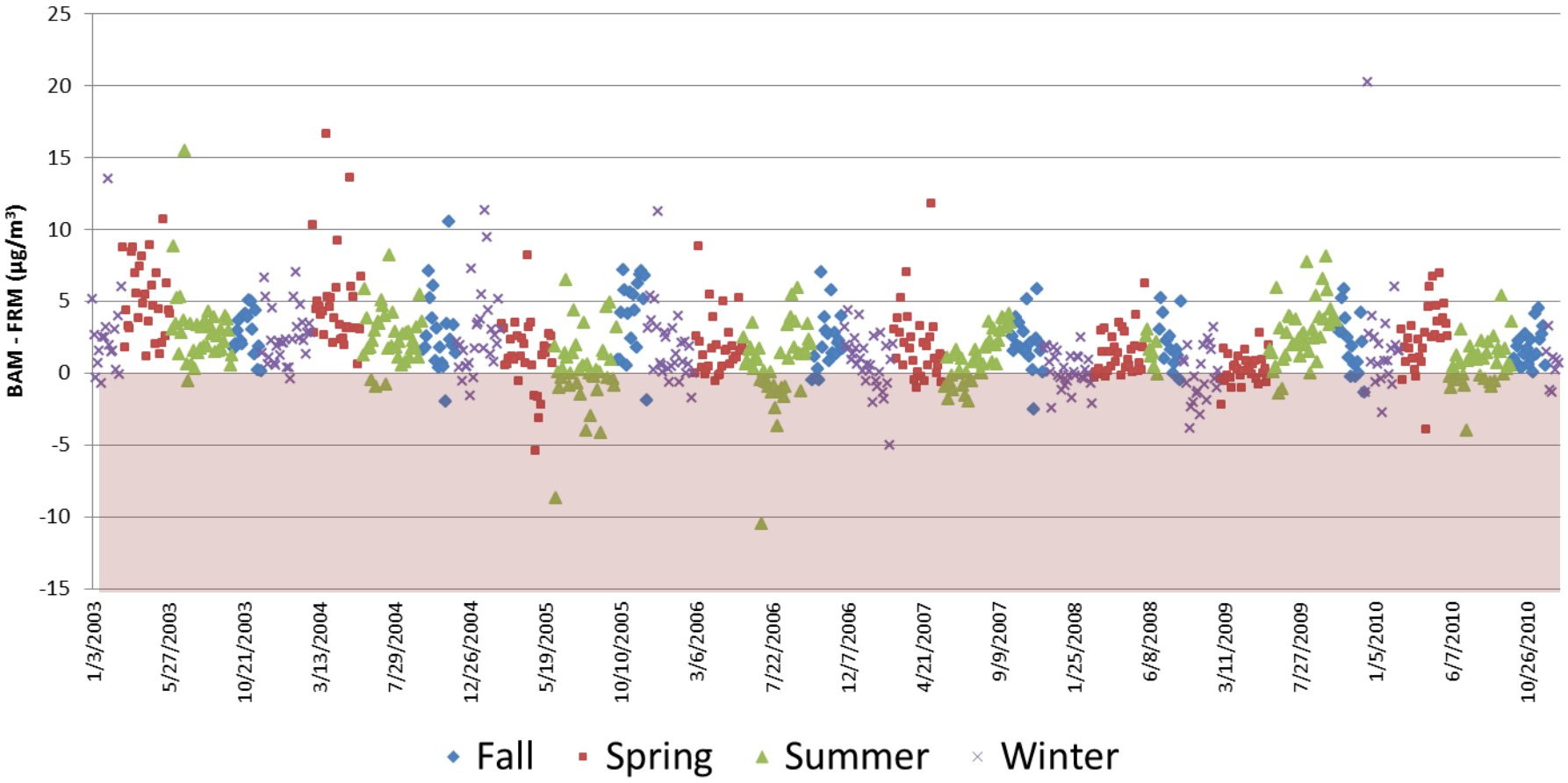






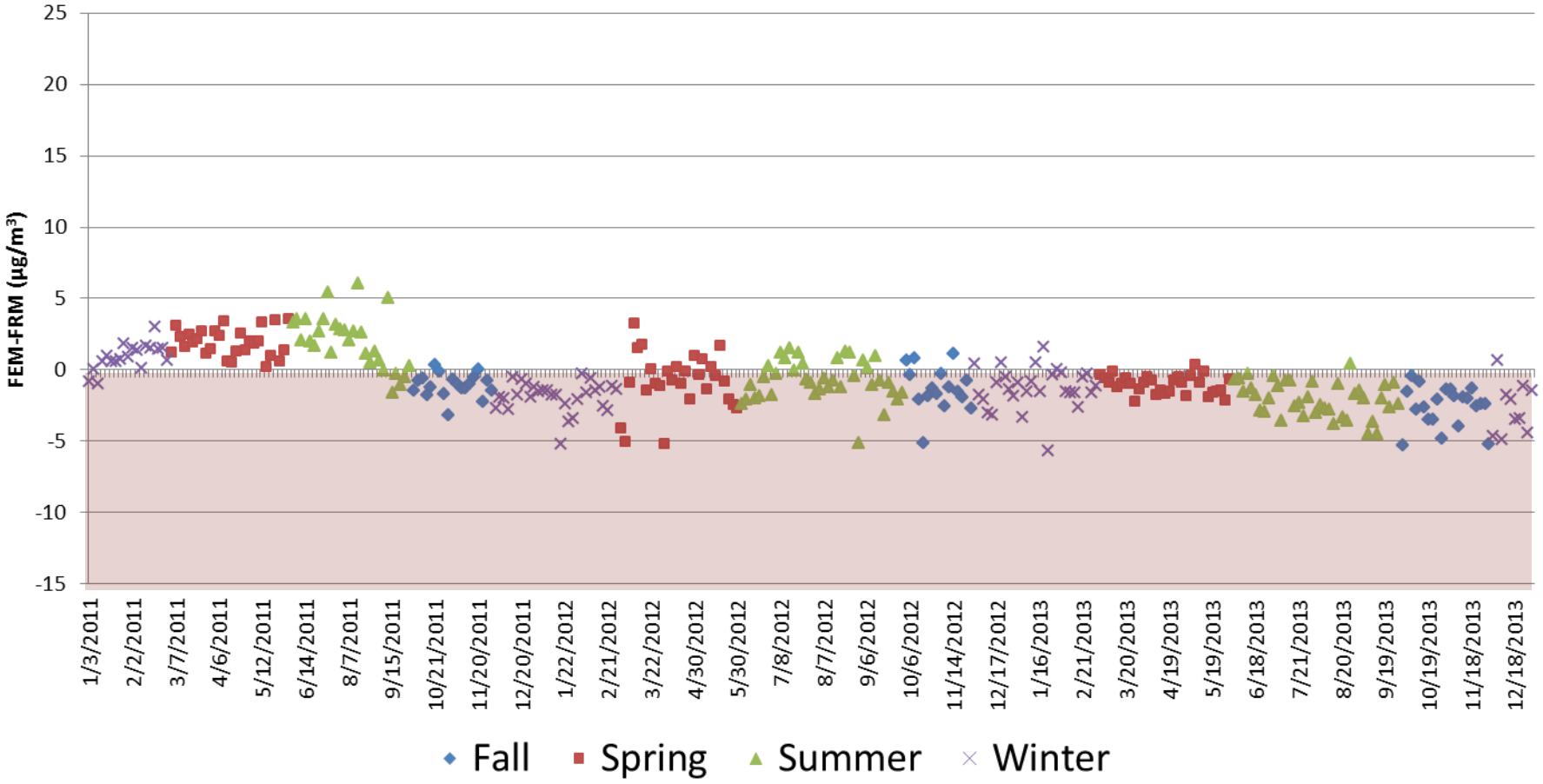
Results: FRM versus Pre-FEM BAM

- 24-HR BAM results routinely higher than FRM
- Evidence of seasonal bias



Results: FRM versus BAM

- 24-HR FEM results now routinely lower than FRM
- Little to no evidence of seasonal bias



What about the other collocated sites?

Operational Changes

Change in BAM operations

- Adoption of FEM monitors (2011-2013)
- Annual background zero-tests (2011)
- Conversion from EDAS to AirVision (2012-2013)
  - Conversion from data logging to direct poll (ongoing)

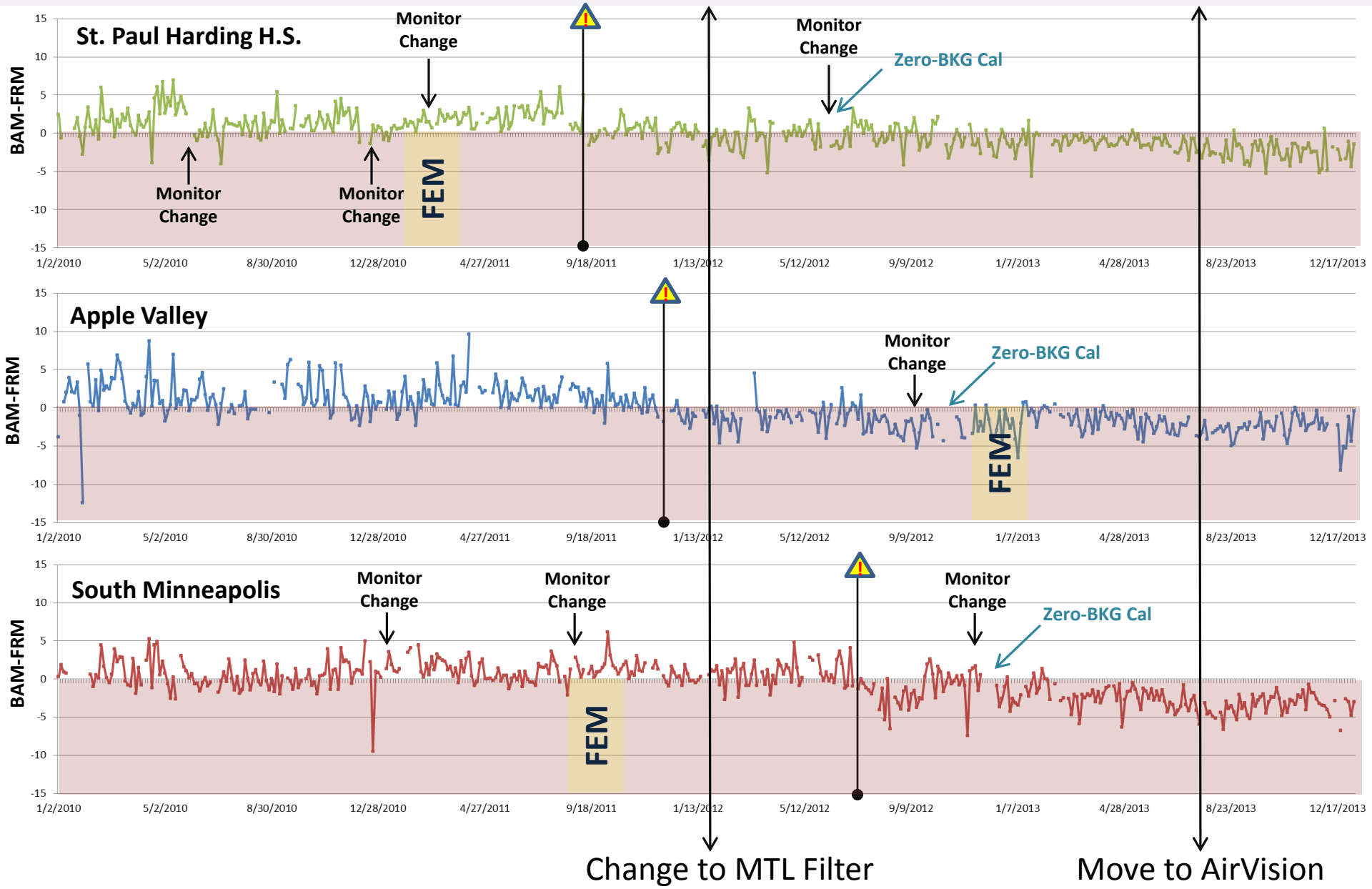
Change in FRM operations

- Replace Andersen with Thermo Partisol-Plus (2009)
- Change from Whatman to MTL PTFE Filters (2012)

Staff turnover

- Field ops
- Data acquisition
- Gravimetric Lab

Timing of Operational Changes



Systems Review: BAM

Invite MetOne to Minnesota

- Review site configuration and operations
- Provide hands-on training for staff

Review zero-calibration procedures

- SOP and vendor procedures sometimes conflict
- Data storage was not centralized (difficult to track)
- Zero-calibration was not consistently performed

Instrument settings

- Majority of monitors reporting analog data
- Monitor not allowed to report negative; offset = 0

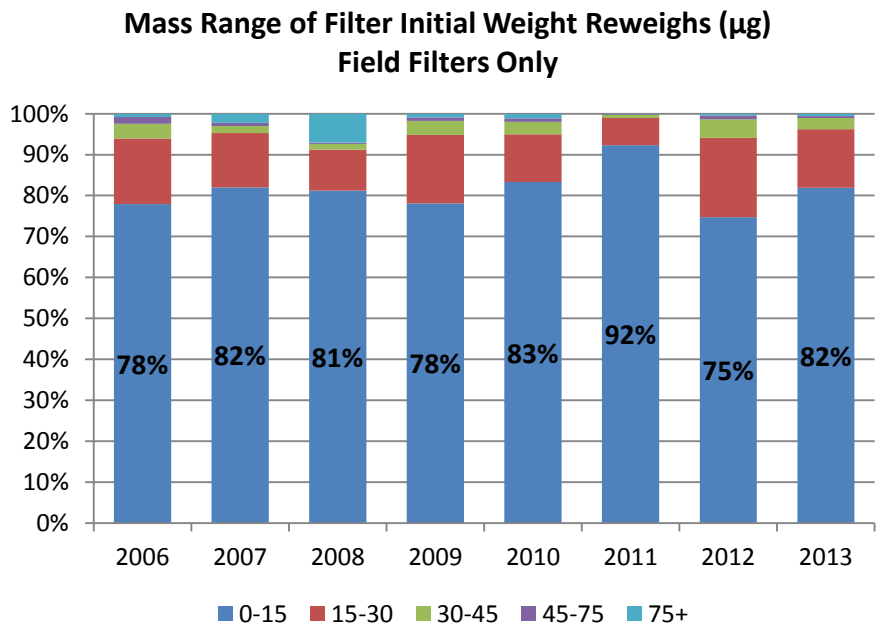
Systems Review: FRM

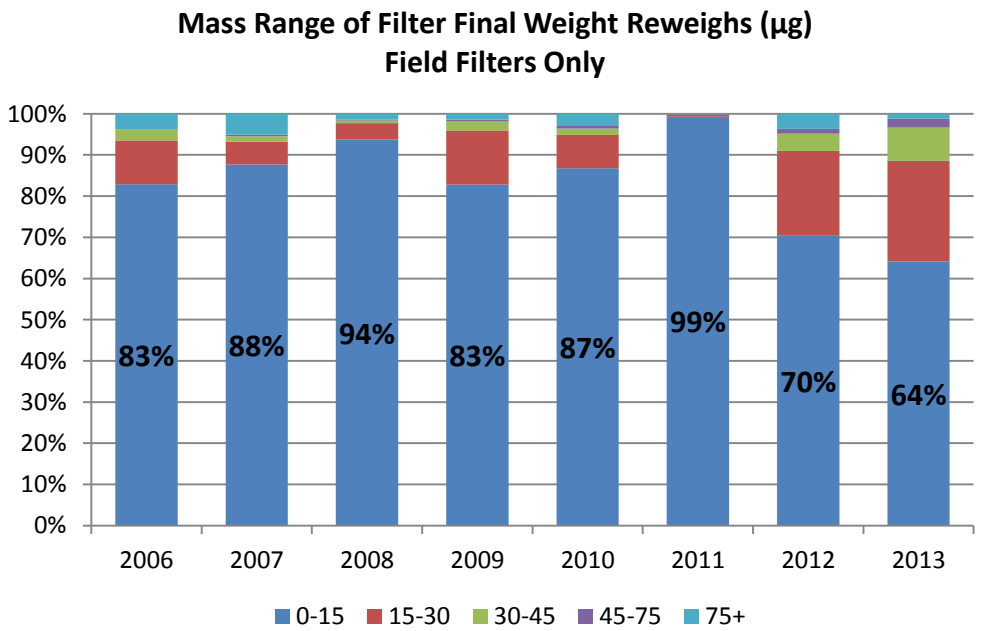
Invite MTL to MPCA

- Review weighing system
- Discuss impacts of new PTFE filters

Review filter weighing system performance data

- Increased noise in live sample reweighs





Systems Review: FRM

We've finally found a problem!

- Noise coincides with adoption of MTL PTFE filter
- MTL filters with PFA support ring will hold more static charge

Most weighing systems effectively discharge the MTL filter

- Canister based weighing systems are ok!
- **Tray based weighing systems are less effective**

Compounding the problem

- Historically lab used first of three weighs to represent mass
- Static charge is the highest during first weigh
- Mass more stable in subsequent weighs

Systems Review: Data Validation

It took us too long to identify the change

System Issues:

- Databases are not linked until data marked final
- Lags in linking sampler data with filter mass results

Process Issues:

- Well established Level I data validation
- Not enough Level II data validation

Lessons Learned

- **Many moving parts**
  - Exact cause of change in FRM/FEM relationship has not been identified
- **FRM and FEM results might be close enough**
  - MN collocated sites are passing annual comparability tests
- **Acceptable performance still impacts results**
  - Monitor combination at a site impacts summary results
  - No mechanism to “correct” FEM data

More Information

Cassie McMahon

Air Quality Research Analyst, Senior
Minnesota Pollution Control Agency
218-302-6600 | cassie.mcmahon@state.mn.us

Rick Strassman

Air Monitoring Unit Supervisor
Minnesota Pollution Control Agency
651-757-2760 | rick.strassman@state.mn.us

Minnesota Pollution Control Agency